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# CONCRETE BRIDGE DECK MANAGEMENT PRACTICES: SUMMARY OF SCANNING TOUR

**Final Report**

## Prepared For:

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**Abstract:**

The purpose of this research was to investigate concrete bridge deck management practices through a scanning tour, including visits with the New York City Department of Transportation (DOT), the Port Authority of New York and New Jersey, the New York State Bridge Authority, the New York State DOT, the New Jersey DOT, the Pennsylvania DOT, and the Colorado DOT. The scanning tour focused primarily on agency organizational structure and experience, quality control procedures, bridge maintenance protocols, and new product evaluation protocols associated with bridge deck joints and surface treatments. In addition, representatives from each DOT escorted the scanning tour members to various bridges with specific deck joint or surface treatment products for inspection.

Before new joint or surface treatment products are approved for use, they should be subjected to both laboratory and field evaluation programs as appropriate. To ensure adequate quality in routine installations, owners may require supervision by manufacturer representatives; product warranties may also be required. In addition, inspections of products may be conducted at individual factories prior to material shipment. Finally, regular bridge inspection and cleaning should be programmed to facilitate early identification of performance problems and permit optimization of maintenance activities.

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# CHAPTER 1
# INTRODUCTION

## 1.1 RESEARCH OBJECTIVE

The purpose of this research was to investigate concrete bridge deck management practices through a scanning tour to several state departments of transportation (DOTs). Research personnel from Brigham Young University (BYU) and engineers from the Utah Department of Transportation (UDOT) visited agencies in New York, New Jersey, Pennsylvania, and Colorado to meet with bridge design and maintenance engineers at those locations. Specifically, the scanning tour included visits with the New York City DOT, the Port Authority of New York and New Jersey, the New York State Bridge Authority, the New York State Department of Transportation (NYDOT), the New Jersey Department of Transportation (NJDOT), the Pennsylvania Department of Transportation (PennDOT), and the Colorado Department of Transportation (CDOT). The scanning tour focused primarily on agency organizational structure and experience, quality control procedures, bridge maintenance protocols, and new product evaluation protocols associated with bridge deck joints and surface treatments.

## 1.2 OUTLINE OF REPORT

This report contains three chapters. Chapter 1 introduces the research objective, and Chapter 2 summarizes the bridge management practices of the agencies visited during the scanning tour. Chapter 2 also provides specific test data collected from several bridge decks inspected during the research. Chapter 3 gives conclusions and recommendations.

# CHAPTER 2

# CONCRETE BRIDGE DECK MANAGEMENT PRACTICES

## 2.1 SCANNING TOUR

Scanning tour visits to the New York City DOT, Port Authority of New York and New Jersey, New York State Bridge Authority, NYDOT, NJDOT, PennDOT, and CDOT occurred between Monday, February 7, 2005, and Friday, February 11, 2005. During the scanning tour, BYU and UDOT personnel met with engineers at the hosting agencies to discuss agency organizational structure and experience, quality control procedures, bridge maintenance protocols, and new product evaluation protocols associated with bridge deck joints and surface treatments. In addition, representatives from each DOT escorted the scanning tour members to various bridges for inspection of specific deck joint or surface treatment products.

BYU personnel performed testing on eight concrete bridge decks owned by NYDOT, NJDOT, and PennDOT; no testing was performed on decks owned by CDOT due to the absence of traffic control. Upon arriving on the deck, the researchers measured the air temperature at the bridge site to facilitate evaluation of the expansion state of the joint. For example, a temperature below the average for the area would indicate that the joint was more open than normal. Then, a short section of the joint was measured, and the debris within that length was removed and placed in a sealed plastic bag; the debris was later dried and weighed to enable computation of the weight of debris per length of joint. A micrometer was then used to measure the joint width, depths to the top and bottom of the joint, and depth of recess below the surface on the joints and armor when applicable. A Schmidt hammer was also used to test the hardness of the surrounding concrete or joint header material in many instances. Finally, the age of the bridge and the presence or absence of curbing were noted. Information obtained during visits to the hosting agencies is provided in the following sections.

## 2.2 NEW YORK CITY DEPARTMENT OF TRANSPORTATION

New York City has about 2,200 bridges, including private bridges between buildings. Of these, 880 are owned by New York City, and 700 are owned by railroad companies; about 25 are drawbridge types. Bridge inspections are performed every 2 years. The scanning tour visit with the New York City DOT focused mainly on the Brooklyn Bridge, which became a national landmark in 1968. The Federal Highway Administration (FHWA) provides funding for bridge preservation activities for this bridge. Walter Kulczycki of the New York City DOT reported that $3 billion was awarded to rehabilitate the Brooklyn, Manhattan, Queensboro, and Williamsburg bridges recently. A photograph of the Brooklyn Bridge is given in Figure 2.1. The suspended span has one expansion joint at the center of bridge. The current average daily traffic (ADT) on the Brooklyn Bridge is 130,000.

The mix of vehicles, bicycles, and pedestrians at the foot of the Brooklyn Bridge was previously problematic due to a lack of channelization. Kulczycki

**FIGURE 2.1 Brooklyn Bridge.**

redesigned the configuration as shown in Figure 2.2 to separate the three modes of transport, thereby improving safety and capacity. The level of service then increased from E to about B+. Depicted in Figure 2.3, the bicycle and pedestrian pathway is 17 ft in width and traverses the entire length of the bridge along its center.

All the decks on the Brooklyn Bridge were replaced in 1998. The estimated project duration was 150 nights. The contractor was offered $45,000 per day for a maximum of 20 days as an incentive for finishing early. He finished in 130 nights and received the maximum bonus of $920,000. Each night he worked from 11:00 p.m. until 6:00 a.m., with the entire side of the bridge under construction closed to traffic. The penalty fee for opening the bridge late each morning was $500 per minute.

Transverse relief joints were placed every 30 ft longitudinally along the deck; an example is given in Figure 2.4. The precast panels were bolted in place, and the joints were seal welded and filled with hot tar before the wearing

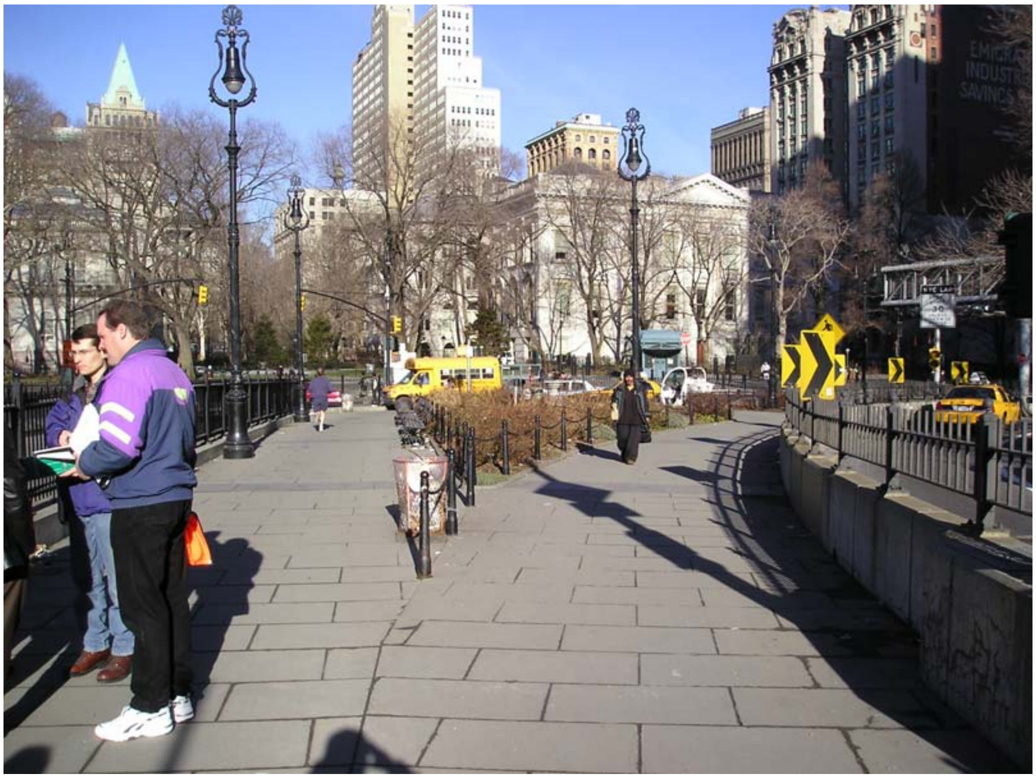

**FIGURE 2.2 Channelization at foot of Brooklyn Bridge.**

**FIGURE 2.3 Bicycle and pedestrian pathway on Brooklyn Bridge.**

course was placed. Orthotropic decks, which are galvanized, concrete-filled steel slabs, were used even though their flexibility can occasionally cause spalling of the wearing surface. In 1980 a Flexolith product had been applied to the bridge deck surface and provided about 12 years of service before failing due to poor bonding. That surface was removed by hydroblasting before a new surface was applied. A two-course surface layer is typically specified for the bridge, where thinner layers have been observed to be more stable than thicker layers. Microsurfacing wearing courses used on the bridge usually provide 5 to 6 years of life; the primary failure mode is thinning in the wheel paths as illustrated in Figure 2.5. An intact substrate is critical for achieving adequate compaction of the wearing course. Kulczycki commented that the wearing course in one direction is performing much better than the wearing course in the other direction because in the latter case, rain fell within 5 hours of the project completion. The existing wearing course is comprised of Trinidad Lake Asphalt.

**FIGURE 2.4  Transverse relief joint on Brooklyn Bridge deck.**

Modular joints, such as the one shown in Figure 2.6, are cleaned every 2 weeks, and a full wash-down of the entire bridge is performed once annually. The drainage system is vacuumed every 4 months. In order to minimize further damage to deteriorating paint, only sound paint is regularly washed. Full repainting is performed every 12 years, and spot repainting is performed every 3 years. A 6-ft to 7-ft high splash zone along the bridge is repainted every 6 years. A contract will be awarded to a private company in 2008 for paint maintenance.

The Brooklyn Bridge Authority uses a relatively standard method of guaranteeing quality control. In-house bridge inspectors monitor the bridge, and, when contractual renovations are made, an approved list of supplies is used.

**FIGURE 2.5 Deck wearing surface on Brooklyn Bridge.**

**FIGURE 2.6 Modular joint on Brooklyn Bridge deck.**

The listed products are standardized and tested by NYDOT.  When the product is no longer covered by a patent, a more detailed specification is used to clearly detail the use and installation of a product.  The resident engineers check and approve the work performed by contractors.  Concerning overall joint and surface treatment performance, Kulczycki commented, “Workmanship quality is it!”

## 2.3 PORT AUTHORITY OF NEW YORK AND NEW JERSEY

The scanning tour visit with the Port Authority of New York and New Jersey focused mainly on the George Washington Bridge, which was completed in 1931. Shown in Figure 2.7, the bridge boasts a clear span of 3,500 ft and has two


**FIGURE 2.7  George Washington Bridge.**

levels. The upper level has eight lanes, while the lower level has six lanes. The addition of the lower deck in 1965 was possible because the bridge structure was originally overdesigned, even by modern standards. The charge for passenger cars to cross the bridge is $6, which is reduced to $4 for EZ-Pass holders, but trucks are charged by the axle, with fees usually totaling greater than $20 per truck. The ADT is 350,000; this traffic level generates annual revenues of $460 million.

Deck joints are provided every 60 ft on the George Washington Bridge. Regarding joint performance, even small aberrations in joint smoothness, such as welding marks or the lugs on orthotropic decks, have caused leaking by interrupting adhesion. Therefore, according to Chan Patel of the Port Authority of New York and New Jersey, the decision was made to install Jeene joints in 1998. A picture of one of the Jeene joint installations is given in Figure 2.8. Patel explained that the Jeene joint possibly provides better results than a regular compression seal due to the inflation process used to install it. Inflating the joint during construction may facilitate a stronger bond between the joint material and the vertical deck surface to which it is epoxied.

This intuitive hypothesis was not supported by field data, however. The Jeene joints began leaking after just 5 months, and all of them failed in less than 1 year. Although the technicians had been trained by the supplier and supervised during the installation process, the company refused to honor the warranty given in the contract. Apparently cleaning the joint faces, which are comprised of weathering steel, had been extraordinarily difficult because the joint openings were typically less than 1 in., making sandblasting very ineffective; indeed, Patel called it a “total disaster.” Therefore, improper surface preparation was determined to be the cause of the premature failure. Working in night conditions probably also adversely impacted the quality of the work. The total cost of the joints was $1.5 million.

Patel noted that the Port Authority planned to next evaluate Dow Corning silicone joints having 1-in. widths. He explained that joint products should be designed to be 1.5 times greater in width than the joints in which they will be

**FIGURE 2.8  Jeene joint on George Washington Bridge deck.**

installed to ensure constant compression on the joint faces.  A few of the silicone joints were installed on the George Washington Bridge 2 years ago and are still under investigation.  Patel observed that in such test sections the products seem to perform quite well, presumably because the contractor and supplier are extremely careful in the installation process.  Unfortunately, routine installations are not often given the same level of care.

The Port Authority of New York and New Jersey is using strip seals with increasing frequency, recognizing that the primary risk is damage to the seal material itself from knife or screwdriver punctures during the installation process. Extra armor anchorages are specified by the Port Authority to ensure enduring retention of armor angles.  The anchorage is tied to the stringers and also to the deck reinforcement.  The reported total cost for strip seal installation on the George Washington Bridge is about $3,000 to $4,000 per lineal foot.  Strip seals may last about 10 years, but the rail extrusions can last 20 years.  For larger movements, on the order of 4 ft to 6 ft, finger joints have been used as depicted in Figure 2.9.  Aluminum troughs are provided beneath the joints and are sufficiently large that a person can enter them to complete maintenance activities.

**FIGURE 2.9  Finger joint on George Washington Bridge deck.**

For headers on full joint replacements, Patel recommends using rapid-set cement or accelerators to achieve early set.  Latex-modified concrete may also be used.  Such repairs may provide 6 months to 2 years of service and perhaps 5 years if the underlying concrete deck is not excessively deteriorated.  The joint block-out should be cut down to about 1 in. below the top mat of reinforcing steel, and the header product should be allowed greater than 6 hours to cure.  Patel noted that thicker patch sections crack more readily than thinner ones.

Temporary joint repairs on the George Washington Bridge are ongoing; consultants are often hired to conduct inspections in the process of identifying needs.  If the joints remain leaky, severe damage to piers, beams, diaphragms, and other bridge substructure elements can result.  Due to the frequency of Yankees games during the summer, lane closures cause excessive traffic congestion; therefore, much of the maintenance is ideally completed during the off season.  Patel explained, “George Washington never sleeps.”  If a lane closure occurs for any reason, the traffic jam often reaches into Connecticut.

For surface treatments on the George Washington Bridge, methyl methacrylate has been used; also, wearing courses about 1.5 in. in thickness have been used.  For surface deicing, sodium chloride salt is regularly applied to the deck; Figure 2.10 depicts salt crystals on a pathway approaching the George Washington Bridge.  Surface icing is not as problematic as the accumulation of ice on the bridge superstructure elements, however.  When such ice sheets fall, cars can be damaged, and accidents can occur.

The current cost to paint the upper level of the bridge alone is $25 million, partially because of abatement efforts required for the presence of lead paint.  A zinc primer is used to enhance protection of painted elements.

**FIGURE 2.10 Salt on pathway approaching George Washington Bridge.**

## 2.4 NEW YORK STATE BRIDGE AUTHORITY

The scanning tour visit with the New York State Bridge Authority focused mainly on the Mid-Hudson Bridge, which is shown in Figure 2.11. Each of the cables in this cable-stayed bridge has 6,080 wires comprising it, which are anchored as illustrated in Figure 2.12. Maintenance activities cost about $15 million annually for this bridge. Revenues from tolls amount to about $40 million each year, with a charge of $1 per vehicle. The ADT is 40,000.

According to William Moreau of the New York State Bridge Authority, the concrete-filled steel grid deck was installed in 1989, about 15 years previous to the scanning tour. An epoxy overlay was applied just after the deck replacement and failed rapidly. The overlay was constantly repaired for 5 years and then removed using hydrodemolition. The current surface treatment used to protect the deck is a Rosphalt Eliminator System, which is reportedly an expensive, spray-on membrane justified in this case because of the significance of this bridge. A wearing surface was placed on top of the membrane.

**FIGURE 2.11  Mid-Hudson Bridge.**


**FIGURE 2.12  Cable anchors on Mid-Hudson Bridge.**

Asphalt plug joints utilized in the bridge deck are 4 in. deep and 20 in. wide at the approach ends as depicted in Figure 2.13. They work best when movements are less than 1 in. and are typically specified for use in conjunction with asphalt overlays. On the deck itself, smaller asphalt plug joints are used, with 3-in. depth and 10-in. width. They were installed in 2002. Moreau explained that the asphalt plug material should have single-sized aggregate and is available from several suppliers, including D.S. Brown, Koch, and Watson Bowman Acme.

A water ponding test was conducted on the first plug joint installed on the bridge. Although the contractor was told that water immersion tests would be

**FIGURE 2.13 Asphalt plug joint on Mid-Hudson Bridge deck.**

performed on the remaining joints as well, the tests were not conducted by the Bridge Authority. This was a strategy to encourage high quality workmanship while simultaneously saving money. The joints were installed with a 1-year warranty. The asphalt plug material does become slightly soft during hot summer days. According to Moreau, the joints should be ideally installed at a median temperature of 55°F, but because most construction occurs during summer, the temperature was instead about 90°F during joint installation on the Mid-Hudson Bridge. Before the asphalt plug joints were installed, strip seals were used. One of the remaining strip seals is shown in Figure 2.14. Moreau commented that elastomeric headers have not performed well on the bridge.

**FIGURE 2.14 Strip seal on Mid-Hudson Bridge deck.**

### 2.5 NEW YORK DEPARTMENT OF TRANSPORTATION

The scanning tour members were hosted by personnel from Region 8 of NYDOT in Poughkeepsie. Region 8 includes 1,143 bridges in seven counties.

Maintenance of these bridges is performed primarily by in-house personnel. Several topics were discussed during field inspections of numerous bridge decks.

Regarding surface treatments, one of the NYDOT bridge maintenance specialists explained that latex-modified overlays are typically applied at a score of about 4 on the National Bridge Inventory (NBI) scale, assuming the substructure and superstructure components are sound. According to Peter Weykamp of NYDOT, chloride concentrations on concrete bridge decks are not measured or monitored. They previously measured half-cell potential values, but they did not feel the effort was “fruitful.”

Joints are often installed by in-house maintenance forces. NYDOT engineers design bridge deck joints for movements based on a temperature range of 150°F to -30°F. Weykamp stated that elastomeric concrete is included on the NYDOT “approved list,” but he has not yet developed a standard specification. For mixing sealants, NYDOT prefers bucket mixers over mortar mixers.

The NYDOT joint specification requires a field representative from the manufacturer to ensure adequate quality. However, the policy has brought limited success because of lack of enforcement; the manufacturer representative is apparently not empowered to mandate the use of correct procedures. Thomas Casarsa of C.S. Behler, Inc. indicated that the cost of manufacturer representation is about $250 to $500 per day. A problem with contractor certification programs is that high turnover rates require constant training by product manufacturers. This “revolving door” costs vendors more money than simply providing in-house personnel to serve as field representatives, so the latter alternative is generally preferred.

Weykamp indicated that NYDOT has previously used modular bridge deck joints and reported a typical life of 10 years. Apparently the joints can be damaged by excessive traffic loading; on the Wurtz Street Bridge over the Rondout Creek, the maximum load was restricted to 5 tons to minimize damage to the modular joints installed on that deck. Modular joints reportedly exhibit frequent maintenance problems as well. Given that the various components of the joints can be difficult to repair, Weykamp said that using modular joints is "like placing a Swiss watch on the deck." The Transflex modular joints installed on one bridge in 1977, however, are only now beginning to need replacement.

For in-house testing of joint products proposed for use by NYDOT, a laboratory jig has been developed that subjects trial joints to a combination of tension and racking forces and temperature cycling. The joint must pass test criteria specified by NYDOT for the laboratory evaluation, and the joint must also provide acceptable in-situ performance over a 2-year monitoring period before it can be approved for statewide use. Usually five or six field installations are required as part of the approval process.

Information regarding specific NYDOT bridges inspected by the scanning tour members is given in Table 2.1, in which hyphens are given where data were not available or where the information was not applicable. Figures 2.15 to 2.22 show pictures of the tested joints. The silicone joints were Dow Corning 902 types. The mean annual air temperature in Poughkeepsie is 49°F, which is quite similar to the air temperatures measured at the time of inspection, so the joint widths were probably at approximately normal values. The silicone joints and XJS system with silicone collected more debris in the tested locations than the Metazeal or Silicoflex joints, probably because of the greater depth at which the silicone joints were installed. In addition, the presence of curbing on two of the three decks with silicone joints may have caused increases in debris entrapment

**TABLE 2.1 NYDOT Bridge Data**

| Description | Facility | | | | |
|---|---|---|---|---|---|
| | 9D/84 | 9W/ Popolopen | 208/Moodna Creek | 94/Moodna Creek | 983W/44 |
| Joint Type | Metazeal | Silicoflex | Silicone | Silicone | XJS System with Silicone |
| Joint Age (yr) | 1.5 | 0.5 | 0.5 | - | 5 |
| Air Temperature (°F) | 51 | 47 | 54 | - | 59 |
| Oven-Dry Weight of Debris (lb/lineal in.) | 0.03 | 0.04 | 0.06 | 0.06 | 0.07 |
| Presence of Curb | Yes | No | Yes | No | Yes |
| Depth to Top of Joint (in.) | 0.65 | 0.47 | 0.78 | 0.79 | 1.40 |
| Depth to Bottom of Folded Joint (in.) | - | 1.85 | - | - | - |
| Width of Joint (in.) | 2.14 | 2.70 | 1.74 | 1.70 | 2.10 |
| Depth of Armor below Concrete (in.) | - | 0.03 | - | - | - |
| Schmidt Rebound Number for Header | 53 | - | 24 | - | 45 |
| Schmidt Rebound Number for Concrete | 31 | 31 | 20 | 27 | 32 |

**FIGURE 2.15  Metazeal joint on NYDOT bridge deck.**

**FIGURE 2.16  Measuring depth of Metazeal joint on NYDOT bridge deck.**

**FIGURE 2.17 Silicoflex joint on NYDOT bridge deck.**

**FIGURE 2.18 Silicoflex joint on NYDOT bridge deck after debris removal.**

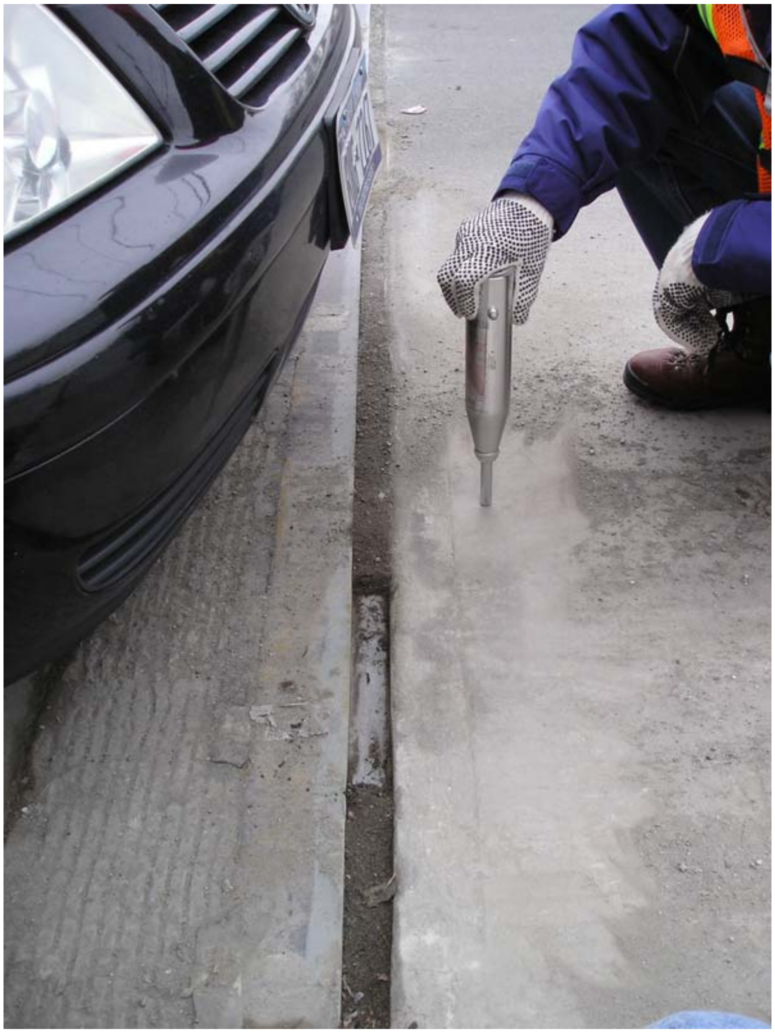

**FIGURE 2.19 Measuring Schmidt rebound number on concrete adjacent to silicone joint on NYDOT bridge deck.**

**FIGURE 2.20 Silicone joint on NYDOT bridge deck.**

compared to decks without curbs. All five of the inspected joints appeared to be intact, however, and NYDOT personnel were apparently pleased with their performance thus far.

In addition to the five NYDOT bridge joints inspected during the visit, a Matrix Blue product was discussed. Weykamp described it as a polysulfide urethane with a backer rod; it failed by debonding during the first spring after installation and had actually been removed or fallen from the joint at the time of the site visit as shown in Figure 2.23. Urethanes are apparently very sensitive to the moisture condition of the substrate, and in this case the joint faces had not been properly prepared.

**FIGURE 2.21  XJS joint system on NYDOT bridge deck.**

**FIGURE 2.22 XJS joint system on NYDOT bridge deck after debris removal.**

**FIGURE 2.23  Failed Matrix Blue joint.**

## 2.6  NEW JERSEY DEPARTMENT OF TRANSPORTATION

The scanning tour visit to NJDOT included an office meeting followed by a few bridge inspections in the Trenton area.  NJDOT is responsible for 2,500 of 6,500 bridges in the state.  Several topics were discussed.

The NJDOT has, at most, two maintenance crews per region.  According to Jose Lopez of the NJDOT, these crews address all types of maintenance and are therefore not specialized in any particular area.  Consequently, NJDOT employs contractors to perform the great majority of inspection and maintenance work.  Because the bid selection process is based on quality rather than cost, with no caps on salaries for “A teams” according to the Brooks Act, this practice is really expensive. Although the process of selecting “best bids” is subjective in nature, few companies have challenged the NJDOT on this issue, probably because the large volume of work permits the participation of large numbers of firms. The NJDOT annual maintenance budget is $17 million.

Regarding bridge management, Jose Lopez of NJDOT explained that each problem identified on the network is assigned “Emergency,” “Priority 1,” or “Priority 2” status. Due to budget constraints, however, “Priority 2” projects are rarely addressed. The primary focus of maintenance actions is road repairs, including potholes, mowing, and other similar activities. Therefore, NJDOT personnel do not “maintain” joints per se; if a snowplow dislodges a joint rail from a deck, repairs will be made, but a leaking joint does not warrant attention under the current NJDOT protocol; water leaking through joints onto the substructure of a NJDOT bridge is shown in Figure 2.24. In addition, rather than scheduling annual bridge washing, the NJDOT relies on natural precipitation to keep the superstructures, substructures, and bridge decks free of debris. Figure 2.25

**FIGURE 2.24 Water leaking through joints of NJDOT bridge deck.**

**FIGURE 2.25 Drainage grate on NJDOT bridge deck.**

shows a drainage grate typical of NJDOT bridge decks inspected in this research.

In New Jersey, most deck joints are installed by contractors, not NJDOT employees. In order of use from small to large joint openings, NJDOT specifies compression seals, strip seals, and modular seals. Field manufacturer representatives are required by NJDOT to be present when modular joints are being installed, but representatives are not required for installation of strip or compression seals; the contractors have reportedly developed sufficient expertise that adequate quality control can be achieved without manufacturer supervision. Water-ponding tests are not required by NJDOT for any joint installations, but Mark Kaczinski of D.S. Brown indicated that ponding tests are commonly used on modular joints in other locations; sand bags are used to hold the water on the deck during the testing.

Kaczinski expressed his opinion that Dow Corning silicone joints and other similar products are not effective long-term joint solutions because they are too sensitive to substrate preparation, shape factor, and joint opening size. For example, he claimed that, although the North Carolina Department of Transportation still permits the use of Evazote, the Maryland Department of Transportation now prohibits its use. Kaczinski suggested that the initial costs of joints too often drive product selection when life-cycle costs should be the actual basis for decision-making. Indeed, NJDOT bridge engineers reported that compression seals begin leaking within 2 years after installation. Examples of deteriorated compression seals inspected on NJDOT bridge decks during the scanning tour are shown in Figures 2.26 and 2.27.

**FIGURE 2.26 Deteriorated compression seal on NJDOT bridge deck.**

**FIGURE 2.27 Traffic wear of compression seal on NJDOT bridge deck.**

According to Kaczinski, strip seals are typically designed for maximum movements of 4 in., but the Texas Department of Transportation reportedly specifies strip seals for movements up to 5 in. Strip seals installed in a 1-in. joint may be impossible to replace, but experienced contractors may be able to replace strip seals installed in 1.5-in. joints. Kaczinski explained that punctures in strip seals may be repaired using silicone adhesive or superglue.

A recent improvement in the steel rails used in conjunction with strip seals is the removal of the upper horizontal flange that previously caused frequent concrete consolidation problems even when numerous holes were provided in the flange to facilitate escape of entrapped air from beneath the flange during construction.  The steel used for making the joint extrusions is usually A36 or A588, which is typically galvanized.  The quality of the anchorage system, rather than the moment of inertia of the extrusion cross-section, is the most important factor in performance according to Kaczinski.  Lopez indicated that NJDOT uses standard anchorage studs supplied by the manufacturers of the products they permit; no additional anchorage bars are added to the systems.  Lopez further explained that racking movements on a given bridge deck should not exceed 10 to 20 percent of the perpendicular movement to ensure satisfactory joint performance.

Concerning joint movements exceeding 6 in., Kaczinski stated that finger joints are too expensive and clog too easily; the increasing price of steel and the fact that ISG now has a virtual monopoly in the market are the primary reasons. He cited National Cooperative Highway Research Program (NCHRP) Report 467 (2002), NCHRP Report 402 (1997), and Chapter 14 of the American Association of State Highway and Transportation Officials Load and Resistance Factor Design Report (2004) as meaningful references documenting the superior performance of modular joints over finger joints.  NJDOT apparently began using modular joints in about 2000, and UDOT has reportedly installed a few experimental modular joints as well.

Many field reports reviewed earlier in this research indicated that modular joints perform extremely poorly.  Kalczinski responded to this observation by explaining that pre-1990 modular joint designs did not correctly account for fatigue; they used a “fillet weld” instead of a “full-penetration weld.”  He suggested that the original European design for modular joints was simply copied in the United States without giving adequate consideration to fatigue and acknowledged that those designs do not yield desirable performance characteristics.  However, he noted that the modular joint systems offered through D.S. Brown have been thoroughly redesigned and suggested that a 20-year service life was a reasonable expectation for the new products.  Modular joints have been installed in California, New York, Tennessee, Texas, and Washington, although only New York, Tennessee, and Texas have adopted the new fatigue provisions in their joint specifications. The DOTs in these states often require a 5-year warranty for modular joints. In Washington, the Tacoma Narrows Bridge uses 19 modular joint cells providing a total movement of 57 in.

Lopez explained that integral and semi-integral abutments are preferred in new construction to avoid placement of joints immediately above bridge substructure supports. In these cases, a poured joint is used between the pavement and approach slabs at the bridge ends. Where possible, the NJDOT has also previously closed joints on existing bridge decks to minimize leakage onto substructure components. In the 1960s and 1970s, joints on bridges with short spans were closed by cutting out a 4-ft section around the joint and filling it with concrete. Small tensile cracks usually occurred, which were then sealed. This practice was applied to bridges that were approximately 35 to 40 years old. UDOT has also occasionally implemented this practice.

NJDOT has maintained a “bare deck” policy for years but is now under pressure to install overlays to maintain deck ride quality. Regarding the common problem of the “bump at the end of the bridge,” Rutgers University is reportedly developing a new design for NJDOT that utilizes an approach slab and a transition slab to address this issue. NJDOT has not yet used any thin-bonded epoxy or urethane deck overlays. A primary problem with urethane products in particular is that in the presence of excess heat, the urethane will react with moisture in the atmosphere and become “spongy.” Indeed, according to David Eixenberger of UDOT, the heat generated by the exothermic reaction itself can cause this problem regardless of the environmental conditions during construction. Instead, NJDOT engineers have specified asphalt overlays for deteriorated bridge decks to maintain ride quality while funding is procured for replacement; the funding procurement process sometimes requires 5 years.

Lopez explained that NJDOT engineers consider the extent of potholing and the magnitudes of chloride concentrations and half-cell potential measurements in order to determine whether a deteriorating bridge deck should be replaced. When spalling and potholes are manifest on more than 30 percent of the deck area, replacement is usually selected. In New Jersey, bridges reinforced with black bar generally begin to exhibit corrosion problems at approximately 20 years of age; if not repaired immediately, these bridges usually require replacement 10 years later. As in other northern states, chloride-induced corrosion of reinforcing steel is a primary mechanism of deck distress in New Jersey. The NJDOT uses calcium chloride extensively for winter bridge deck maintenance.

New deck construction utilizes high-performance concrete with 9.5-in.-thick decks. Because Type III Portland cement is reportedly unavailable in New Jersey, high amounts of Type I and Type II Portland cements are typically used to produce high early strengths; the high-performance concrete specification has been in use as a standard since about 2003. NJDOT engineers have noted that high-performance concrete and their “Class A” concrete both experience cracking as displayed in Figure 2.28, presumably due to a combination of hydration and evaporation shrinkage. Both epoxy and galvanized reinforcing bars are specified for new construction, although the latter is less common due to

**FIGURE 2.28 Cracking in new NJDOT bridge deck.**

the sporadic availability of galvanizers in the area. As needed, Sika Pronto 19 is applied as a deck sealer, but surface treatment and deck joint maintenance programs are notably reactionary rather than preventive in New Jersey.

NJDOT engineers responsible for state bridges recognize the need to clearly demonstrate to legislators the positive impact of preventive maintenance on future bridge condition in order to obtain funding for preventive maintenance work. However, although NJDOT personnel do follow the NBI inspection requirements and include element-level ratings, they are not presently using an electronic database such as PONTIS to facilitate condition monitoring.

Although the scanning tour members visited several NJDOT bridges, only one deck was inspected in detail; information for that deck is given in Table 2.2, and Figures 2.29 and 2.30 provide photographs of the deck joint. As in Table 2.1, hyphens are given where data were not available or where the information was not applicable. The mean annual air temperature in Trenton is 53°F, so the joint was probably very close to its average width during the inspection. The strip seal was set deeper than the joints inspected in New York and held significantly more debris. The presence of a curb and the absence of a bridge washing program in New Jersey may also have been partially responsible for the relatively high amount of debris in the joint.

**TABLE 2.2 NJDOT Bridge Data**

| Description | Facility |
|---|---|
| | Dunns Mill Rd/295 |
| Joint Type | Strip Seal |
| Joint Age (yr) | 11 |
| Air Temperature (°F) | 53 |
| Oven-Dry Weight of Debris (lb/lineal in.) | 0.17 |
| Presence of Curb | Yes |
| Depth to Top of Joint (in.) | - |
| Depth to Bottom of Folded Joint (in.) | 3.26 |
| Width of Joint (in.) | 1.20 |
| Depth of Armor below Concrete (in.) | 0.05 |
| Schmidt Rebound Number for Header | 34 |
| Schmidt Rebound Number for Concrete | 31 |


**FIGURE 2.29  Strip seal on NJDOT bridge deck.**

**FIGURE 2.30 Strip seal on NJDOT bridge deck after debris removal.**

## 2.7 PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

The scanning tour visit to PennDOT included an office meeting followed by a few bridge inspections in the Harrisburg area. Pennsylvania has more than 25,000 bridges statewide that are greater than 8 ft in length. Several topics were discussed.

Each county in Pennsylvania has a bridge crew to address bridge maintenance issues. According to Scott Christie of PennDOT, score cards are utilized to monitor joint cleaning, drain cleaning, deck sweeping, and bearing seat cleaning for each bridge within the PennDOT jurisdiction. Cleaning of bridges is typically performed during the months of March and April with in-house personnel, although some districts and counties have separate budgets that permit them to hire contractors. The procedures for such actions are centralized, but PennDOT is decentralized as an agency; the main office updates standard drawings and details and provides oversight for quality assurance uniformity, but individual districts are responsible for their own decision-making and management activities. In fact, the districts manage 100 percent of all routine projects. Because decks, sign structures, and other common elements of construction are specified in the standard drawings, the district engineers do not actually perform significant amounts of design work.

In 1985 and 1986, PennDOT created an in-house bridge management system to address specific bridge management activities in Pennsylvania. Even though Christie believes that PONTIS is probably a better tool than the original PennDOT program, PennDOT engineers have not yet upgraded to the new software. Christie suggested that they will likely begin using PONTIS in the near future, however.

Christie indicated that compression seals are not generally used in Pennsylvania any longer. In fact, most of the compression seals were removed from service between 1987 and 1990 and replaced with strip seals. One problem Christie noted with the compression seals is that they were readily dislodged by passing snow plows. Also, the compression seals would occasionally fall out of the joints, which was the case with Clarks Ferry Bridge.

Strip seals are specified by PennDOT when the minimum movement is at least 3 in. and the maximum movement is less than 4 in., although strip seals have been successfully installed in locations where 5 in. of movement was expected. Although early strip seal products were known by PennDOT engineers to tear somewhat easily, more recent products have exhibited improved durability. Since the first strip seal installations in Pennsylvania in 1987, no major problems with strip seals have been reported; Christie expects 18 to 20 years of life from most of them and feels that many will last longer. PennDOT uses both painted and galvanized armor and joint extrusions.

In addition to strip seals, PennDOT has installed finger joints with troughs and some modular joints. Example finger joints are depicted in Figures 2.31 and 2.32. The troughs used in conjunction with the finger joints are commonly constructed of neoprene and installed with a 1:12 slope. Each trough is routinely cleaned at the end of each winter. In one case, the first time a trough was cleaned, maintenance personnel had to partially disassemble the joint to remove

**FIGURE 2.31  Debris in finger joint on PennDOT bridge deck.**

pigeon nests and other debris that had blocked the drainage. Figure 2.33 shows a trough beneath a finger joint. PennDOT participated in early research on modular joints and concluded that poor design, low-quality components, and poor installation were all responsible for the inadequate joint performance observed in their studies; based on this experience, PennDOT is “staying away” from modular joints at the present time. Therefore, for deck movements exceeding 5 in., finger joints are currently specified.

Regarding other joint types, one Silicoflex joint was installed by PennDOT in 1999, and asphalt plug joints, such as the one shown in Figure 2.34, are often

**FIGURE 2.32 Newly installed finger joint on PennDOT bridge deck.**

used in asphalt overlays of bridge decks. Dow Corning silicone joints have also been used and reportedly exhibit an average service life of 10 years.

Contractors can submit value engineering proposals requesting the use of other products as well. PennDOT's product evaluation program, which is administered through the construction division, requires that a unique experimental plan be developed for each proposed product. Once a given product is pre-approved, the product vendor can petition contractors to submit value engineering proposals to PennDOT for consideration; in such cases, the vendor must convince the contractor of any financial benefits or construction advantages of the trial product over the original selection. Funding for product

**FIGURE 2.33  Trough beneath finger joint in Pennsylvania.**

evaluations is usually supplied by the product vendor and the PennDOT Office of Research, and petitions for product evaluations are evaluated by a team of four to five engineers responsible for selecting products of interest and designing appropriate testing protocols.  Some vendors initially circumvent this formal selection process by convincing PennDOT bridge maintenance coordinators to try new products on small bridges.  If the product exhibits good performance over a period of time, the vendor may then be more successful in petitioning for a formal product evaluation.

D.S. Brown and Watson Bowman Acme are the primary suppliers of bridge deck joint products in Pennsylvania.  PennDOT had apparently required heavier anchorages than the standard anchorages originally provided by the suppliers; after some time, the suppliers then adopted the PennDOT specifications as the new standard.  The specification requires two rows of studs at 12- to 18-in. spacing, and the anchorages must be tied to the deck

**FIGURE 2.34  Asphalt plug joint on PennDOT bridge deck.**

reinforcement.  Bridge inspectors have been taught to tap the studs with a hammer to quickly check weld quality.

Field representatives are usually required only on first-time installations of new joint products; afterwards, the contractors are presumed to be capable of ensuring quality construction.  Water-tightness and other performance-related tests are performed during product evaluation with the field representative, but such tests are not typically performed thereafter.  However, the PennDOT Bureau of Construction does maintain contracts with private companies to travel to fabrication locations to ensure that proper manufacturing processes are applied to the production of joint extrusions and other components.  In some cases, PennDOT engineers also perform these inspections. The products are then assumed to function adequately unless inspection personnel report otherwise.

Like UDOT, PennDOT does try to eliminate joints on existing deck structures during rehabilitation or reconstruction activities. PennDOT's design for jointless bridges, even up to 1,000 ft in length, includes 25-ft cantilevered ends that meet the pavement slabs over a concrete box provided immediately beneath the joint to facilitate drainage; the concrete culvert apparently serves the same purpose as "sleeper slabs" utilized by other agencies but also collects runoff from the deck. With an integral abutment, PennDOT uses a separate joint, which could be a strip seal, finger joint, or asphalt hot-pour. If a non-integral abutment is utilized, then a simple relief joint with asphalt hot-pour sealant is usually specified. PennDOT engineers have noted that pavement slab migration can close or even crush the joint between the pavement and the approach slab to the deck.

PennDOT currently designs new bridge decks to be able to sustain additional dead load associated with future overlays. PennDOT engineers assume overlays will add approximately 30 lbs per square foot to the deck. Harivadan Parikh of PennDOT prefers to place latex-modified overlays on new decks, not aged decks with 30 percent potholes. Historically, however, the FHWA would not assist with funding for such overlays; at the present time, the FHWA will consider participating in overlay projects on a case-by-case basis if the overlay is included in the original construction plans. The New Jersey Turnpike Authority has been using latex-modified overlays for the last 2 years.

PennDOT reports that, due to geographic variability in the quality of construction materials, not all areas of the state follow the same practices. For example, latex-modified overlays are not applied in some areas of the state because of observed delamination problems with the product. In such cases, PennDOT may use bituminous membranes with asphalt overlays to extend bridge deck service life an additional 5 to 10 years.

In new construction, PennDOT has been specifying a minimum concrete clear cover of 2.5 in. over the top mat of reinforcing steel since the 1980s, although in the 1960s a cover of just 1.5 in. was required over black bar. Like UDOT, PennDOT has experienced previous problems with low clear cover in the center of double-overhang bridges. In the 1980s, cover thickness was routinely measured; however, PennDOT does not currently measure cover thickness unless a problem is expected. The minimum deck thickness specified by PennDOT is 8 in., and most decks are less than 12 in. thick. Currently, pre-cast concrete beams are used for 95 percent of the bridge decks with spans less than 150 ft. Environmental concerns associated with repainting steel beams may be a leading factor influencing this statistic. Regarding reinforcement materials that may offer greater resistance to corrosion, Christie observed that galvanized bars can become brittle at bends due to the galvanization process. MMFX bars have been installed by PennDOT as well, but the installations were reportedly too recent to permit reliable assessments of performance.

PennDOT has been using stay-in-place metal forms (SIPMFs), as depicted in Figure 2.35, for more than 30 years and has not received any reports suggesting that the presence of the forms causes accelerated corrosion of the steel deck reinforcement. While the inability to inspect the lower concrete surface of decks with SIPMFs is admittedly a problem, PennDOT engineers explained that localized rusting and failure of the galvanized SIPMFs is a reliable indicator of deck failure in cases where failure is associated with water flow through the deck. PennDOT also applies overlays to decks with SIPMFs, even though this practice further reduces the efficacy of visual inspections. To discuss design and construction details for bridges and other structures, PennDOT participates in a meeting twice a year with other states in the New England area, including Delaware, the District of Columbia, Maryland, New Jersey, New York, Virginia, and West Virginia.

Information regarding specific PennDOT bridges inspected by the scanning tour members is given in Table 2.3, and Figures 2.36 through 2.40 illustrate decks tested in Pennsylvania. As stated previously, hyphens are given

**FIGURE 2.35  Stay-in-place metal forms on PennDOT bridge deck.**

**TABLE 2.3  PennDOT Bridge Data**

| Description | Facility | |
|---|---|---|
| | US 22/Susquehanna River | Ramp/US 22 |
| Joint Type | Silicoflex | Strip Seal |
| Joint Age (yr) | 5 | 5 |
| Air Temperature (°F) | 40 | 40 |
| Oven-Dry Weight of Debris (lb/lineal in.) | 0.16 | 0.12 |
| Presence of Curb | Yes | Yes |
| Depth to Top of Joint (in.) | 0.58 | - |
| Depth to Bottom of Folded Joint (in.) | 1.80 | 2.85 |
| Width of Joint (in.) | 3.50 | 1.94 |
| Depth of Armor below Concrete (in.) | - | - |
| Schmidt Rebound Number for Header | - | - |
| Schmidt Rebound Number for Concrete | - | - |

**FIGURE 2.36  Silicoflex joint on PennDOT bridge deck.**

where data were not available or where the information was not applicable.  The mean annual air temperature in Harrisburg is 51°F, so the joints were more open than normal during testing.  The joints collected similar amounts of debris, even though the Silicoflex joint was substantially wider.  The Silicoflex joint was debonded from the armor angle in one location as indicated in Figure 2.38, but otherwise both joints seemed to be performing satisfactorily.


FIGURE 2.37  Silicoflex joint on PennDOT bridge deck after debris removal.

FIGURE 2.38  Bonding failure of Silicoflex joint on PennDOT bridge deck.

**FIGURE 2.39  Strip seal on PennDOT bridge deck.**


**FIGURE 2.40  Strip seal on PennDOT bridge deck after debris removal.**

## 2.8  COLORADO DEPARTMENT OF TRANSPORTATION

The scanning tour visit to CDOT included an office meeting followed by a few bridge inspections within the Transportation Expansion (TREX) project corridor in Denver.  Several topics were discussed.

CDOT inspects 3,700 on-system bridges, and contractors are hired to inspect the 4,200 off-system bridges within the state of Colorado.  CDOT has nine bridge inspectors for conducting on-system inspections and three consulting engineers for conducting off-system inspections.  Deficiencies identified in the inspections are reported to the appropriate bridge maintenance managers within the six CDOT regions, which are each serviced by a separate maintenance unit. Previously, bridge maintenance was not funded as a line item in the state budget, so maintenance activities were largely discretionary.  However, since the year 2000, CDOT has been awarded annual budgets of $9 million for bridge maintenance and $30 million for bridge rehabilitation and replacement.  The bridge maintenance funding is allocated at the discretion of the bridge maintenance managers in the individual regions. Region 4 is the only region within CDOT with a dedicated bridge maintenance group; their maximum permissible project cost is $50,000.

CDOT is developing a bridge classification system to identify preventive maintenance needs, reactionary maintenance needs, and critical inspection needs. CDOT's long-term goal is to use PONTIS for bridge management activities, but the current focus is on expansion joint devices, deck deterioration, and water drainage.

Regarding expansion devices, CDOT classifies joint movements into three categories: 0 to 2 in., 0 to 4 in., and 4 in. or greater. In the first category, asphalt plug joints are used if bridge skews are less than 15 to 20 degrees and the joint movement is less than 1 in.; otherwise, compression seals may be used. An asphalt plug joint installed on a skewed angle is shown in Figure 2.41, and a compression seal is shown in Figure 2.42. Strip seals are primarily used in the second category, and modular joints are generally used in the third category.

Apparently, CDOT has not been pleased with waffle- or foam-type compression seals because they fall out of the joints over time. In support of this position, Richard Miles of Bowman Construction Supply, Inc. expressed his opinion that caulking-type joint seals are not reliable long-term solutions because adhesion is not as reliable as mechanical interlock. He commented that the smooth surfaces required for optimum adhesion cannot be readily achieved in the field by typical bridge contractors. Furthermore, he observed, for example, that the European use of plug joints is limited to accommodating only rotational movement, and that strip seals are mainly used to accommodate longitudinal deck movement.

Concerning problems with inadequate concrete consolidation beneath joint armor, Miles recounted some earlier experimentation with which he was involved. He explained that an early joint armor design incorporated 0.5-in.-diameter vent holes spaced at 18-in. intervals; when that configuration was found to be insufficient, the design was changed to include 1-in.-diameter holes spaced at 12-in. intervals. Finally, the manufacturer suggested that epoxy should be

**FIGURE 2.41 Asphalt plug joint on CDOT bridge deck.**

pressure-injected into the vent holes following installation, but 95 percent of the projects did not follow this specification.

Also regarding joint armor, Miles has observed that bends in anchorages often fatigue and that, once one is broken, the remaining anchor bends begin breaking “like a zipper.” He suggested that a significant factor causing fatigue is the downward force of traffic on the cantilevered armor steel. Therefore, in an attempt to reduce the exposure area of the armor steel at the deck surface, he developed a new design in 2001; as shown in Figure 2.43, the new design eliminates the horizontal component of traditional armor angles that is associated with poor concrete consolidation and also embeds the armor steel within the

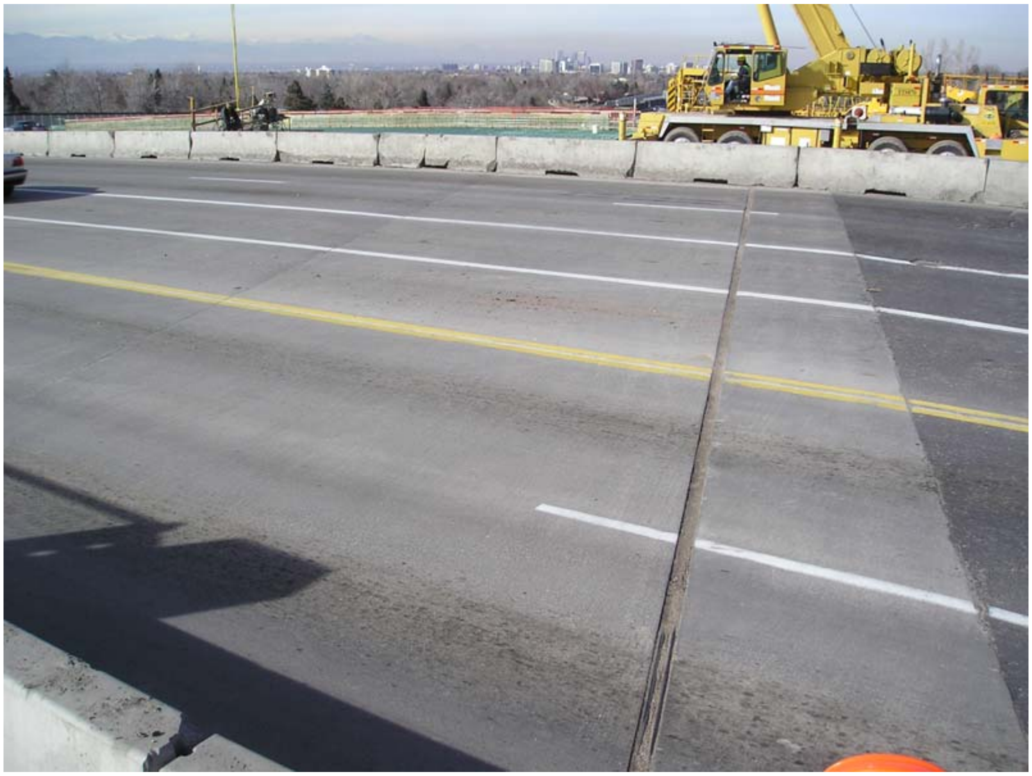

FIGURE 2.42  Compression seal on CDOT bridge deck.

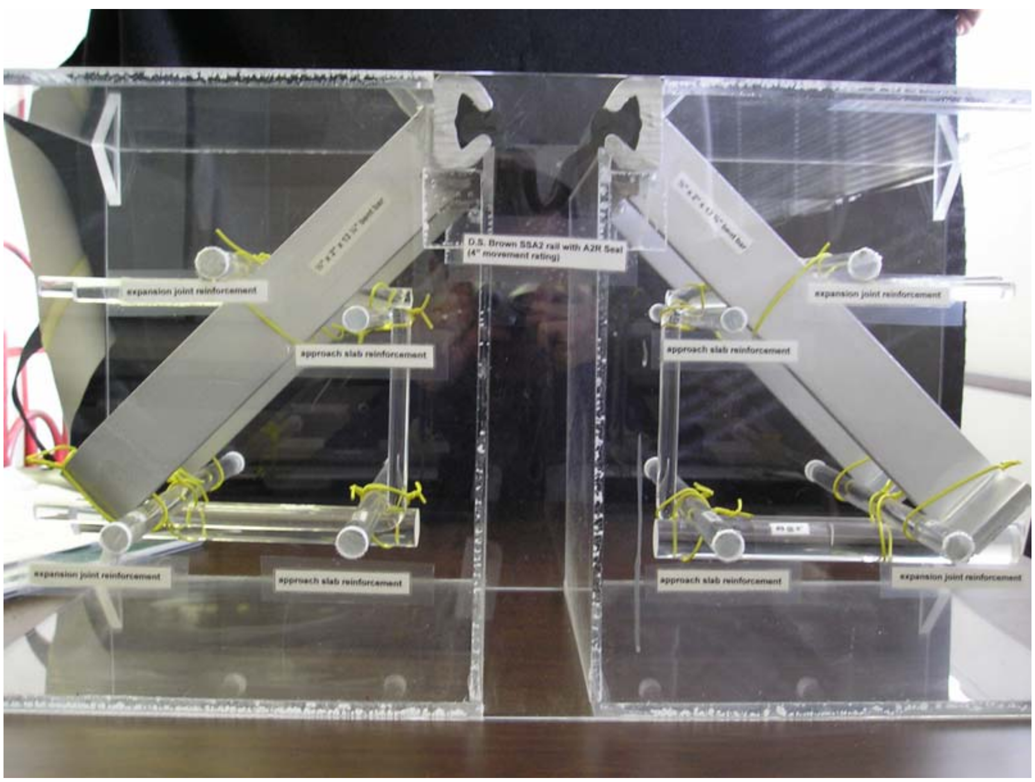


FIGURE 2.43  Custom joint anchorage.

concrete.  Miles asserted that 0.5-in.-diameter studded anchors are too weak and that the new anchorage design includes a 5/16-in. fillet weld around the connection between the anchorage and the rail.

Miles purchases materials from D.S. Brown and then fabricates his specialty joints through contracts with a partner company.  He commented that longitudinal welds on early armor angle joints often caused twisting, bending, and warping, but the new style is straightened before and after galvanization to ensure high quality upon delivery.  He noted that the new style is still sufficiently flexible to accommodate bending to match cross-section slopes.

While a 0.25-in. vertical joint recess is recommended by Miles, he has observed that the recess is “fairly irregular” due mainly to careless contractor workmanship.  On some occasions, deck joints set above the surface of the deck have been struck by snowplows so forcefully that the engagement caused the driver to lose control of the snowplow.  Therefore, Miles has also designed a strip seal joint specifically manufactured to be resistant to snowplow damage; the joint is depicted in Figure 2.44.

Concerning protection of joint armor from corrosion, Miles indicated that galvanizing is much more durable and economical than painting, and, as a result, paint has not been used on CDOT jobs for years.  Rubber glands supplied for strip seals through D.S. Brown, for example, reportedly last up to 20 to 25 years, with a 15-year life easily achieved.  He also reported that, to ensure a long joint life, the Wyoming DOT sometimes fills strip seals with clean sand to prevent collection of lug nuts, bolts, and other debris from being trapped within the joint over time.  In addition, joint seals should be turned up at the parapets and installed at a minimum height of 6 in. above the top of the deck.  Miles believes that failures of joints exhibiting less than 5 years of service life are probably associated with poor design, construction workmanship, and/or materials; joints should provide a minimum of 15 years of service.

Miles commented that epoxy-based joint headers do not perform as well as urethane headers; the epoxy-based headers are too stiff and come out in blocks.  He feels that using urethane headers minimizes the brittleness that

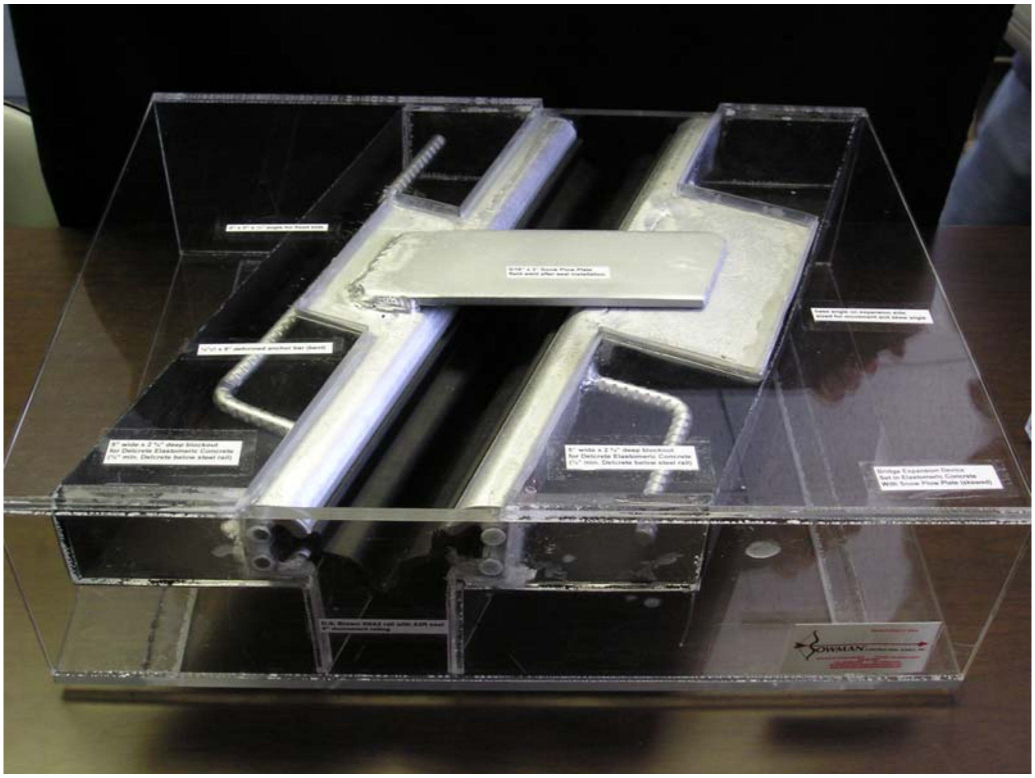

**FIGURE 2.44  Custom joint designed to resist snowplow damage.**

occurs with aging and cold temperatures.  Both D.S. Brown and Watson Bowman Acme now offer products comprised of 100 percent urethane.  The joint must be thoroughly dry before application of the urethane, however, as moisture in the concrete can adversely affect urethane products.  According to Miles, some agencies have developed high-early-strength concrete that can be mixed on site and that develops compressive strengths of 5,000 psi in 2 hours.  TransPatch is supposedly the only material that does not generate cracks within 2 weeks, however.

The cost to replace strip seals is about $1,000 per lineal foot in the Denver area, due mainly to traffic control costs.  Specifically, Miles suggested that 40 percent of the budget is expended on traffic control, 20 percent on “awkward phasing,” and the balance on materials costs.  In addition to maintaining strip seals, CDOT has several modular joints, each approximately 40 ft in width, which were installed in about 1987.  Although some are still performing satisfactorily, most have just reached 15 years of age and are extremely difficult and expensive to repair or replace. Therefore, in rehabilitation activities, CDOT tries to eliminate joints or reduce the movement so the joint falls into a lower category, and, in new construction, CDOT uses primarily integral abutments to reduce the number of required deck joints.

According to the CDOT specification, manufacturer representatives should be present during all phases of expansion joint construction, but in practice they are usually only present for gland installations. According to Miles, who works with about seven or eight contractors who perform this kind of construction, the field representative should provide any specialty equipment for contractors to use during joint construction and serve as a resource to contractors. Nonetheless, he explained, “Many contractors consider someone like me to be nothing more than an impediment to progress on a project.” Poor construction workmanship is exacerbated by the fact that, since joint installation is the last item on a bridge project, “leftover” personnel usually perform most of the work.

For placement of surface treatments on concrete bridge decks, Leonard explained that CDOT is currently considering measuring chloride concentrations at the level of the upper mat of deck reinforcing steel as a means of determining optimum timing of applications. However, he has yet to determine whether the use of 1.0, 1.5, or 2.0 lbs of chloride per cubic yard of concrete will be more appropriate for deciding whether applications of preventive maintenance treatments will be effective. Essentially, CDOT engineers would like to be able to determine whether future preventive or reactionary maintenance treatments can be programmed for individual decks based on current deck condition.

Since about 1975, CDOT has specified the use of asphalt membrane systems for sealing decks, even placing asphalt overlays on decks adjacent to Portland cement concrete pavement. The asphalt overlays were usually 3 in. in thickness so that 2 in. could be milled off and replaced during rehabilitation without disturbing the underlying membrane. However, CDOT engineers are increasingly implementing a bare-deck policy. The use of asphalt membranes requires maintenance and attendant traffic control every 5 to 8 years, and CDOT does not feel that maintaining “little patches of asphalt” along a facility paved mainly with concrete is cost efficient. Nonetheless, asphalt membranes are being placed with a 2.5-in. stone matrix asphalt overlay on new decks in the Transportation Expansion (TREX) Project. Sleeper slabs are also being incorporated in the TREX project as shown in Figure 2.45.

**FIGURE 2.45 Sleeper slab on CDOT bridge in TREX project.**

# CHAPTER 3
# CONCLUSION

## 3.1 SUMMARY

The scanning tour members inspected bridges maintained by agencies in New York, New Jersey, Pennsylvania, and Colorado to investigate concrete bridge deck management practices in those agencies. Specifically, the scanning tour included visits with the New York City DOT, the Port Authority of New York and New Jersey, the New York State Bridge Authority, NYDOT, NJDOT, PennDOT, and CDOT. The scanning tour focused primarily on agency organizational structure and experience, quality control procedures, bridge maintenance protocols, and new product evaluation protocols associated with bridge deck joints and surface treatments. In addition, representatives from each DOT escorted the scanning tour members to various bridges with specific deck joint or surface treatment products for inspection.

BYU personnel performed testing on eight concrete bridge decks owned by NYDOT, NJDOT, and PennDOT, including measurements of joint dimensions, debris accumulation, and Schmidt rebound numbers of adjacent header and concrete materials. Finally, the age of the bridge and the presence or absence of curbing were noted.

## 3.2 FINDINGS AND RECOMMENDATIONS

Regarding joints, compression seals are commonly used to accommodate joint movements less than 1 in., but weld marks on joint rails or other non-uniformities along the joint edges can disrupt joint adhesion and cause premature joint leakage. Compression joints relying strictly on adhesion for water-tightness may not provide satisfactory long-term performance. Asphalt plug joints have been used successfully, however, to accommodate small movements on decks with skew angles less than 15 to 20 degrees. Strip seals are typically used to accommodate joint movements up to 4 or 5 in. The anchorages should be tied to the deck reinforcement, and custom joint rails may be specified to achieve improved consolidation of concrete behind the rails and greater resistance to snowplow damage. The rails should be galvanized or coated with a zinc primer to maximize service life. To accommodate joint movements of 6 in. or greater, either finger or modular joints may be utilized. Modular joints have not yet proven to be reliable, and some agencies therefore use finger joints exclusively. Troughs must be installed beneath finger joints, however, and both types of joints should be cleaned regularly to ensure satisfactory performance.

Concerning surface treatments, DOT personnel should consider applying protective overlays before chloride concentrations reach critical levels in the vicinity of the reinforcing steel in the deck. On deteriorated decks, bituminous membranes with asphalt overlays are commonly installed to extend bridge deck service life an additional 5 to 10 years. The quality of the substrate preparation and climatic conditions at the time of construction can both affect the performance of overlay products.

Before new joint or surface treatment products are approved for use, they should be subjected to both laboratory and field evaluation programs as appropriate. Engineers should also note that field test sections may not be representative of future product performance because of elevated workmanship quality often associated with test sections. To ensure adequate quality in routine installations, owners may require participation of manufacturer representatives, who should be empowered to enforce the project specifications. Product warranties may also be required. In addition, inspections of products may be conducted at individual factories prior to material shipment. Finally, regular bridge inspection and cleaning should be programmed to facilitate early identification of performance problems and permit optimization of maintenance activities.